Claims

1. Method for the manufacture of components composed of difficult-to-cut materials for gas turbines, especially for aircraft engines, by producing recesses with one or more side walls, in particular for manufacturing integrally bladed rotors for gas turbines, the recesses forming flow channels and the side walls forming blade surfaces, comprising the following steps:
   a) defining contours of said recesses by defining contours of at least one of said side-walls and said flow channels,
   b) removing material in the region of said flow channels by a drilling process,
   c) after the drilling process is finished, completing the removal of material in the region of said flow channels by a milling process.

2. Method according to claim 1, wherein the drilling process is performed in a way that a drilling tool removes material by drilling drill-holes, wherein at least one of the size of the drill-holes, the pattern of the drill-holes and the axis of the drill-holes is determined from the defined contours of said recesses.

3. Method according to claim 2, wherein the drilling process is performed in a way that a drilling tool removes material in a flow wise direction of each flow channel, and the axis of the drill-holes is approximately in parallel to the flow direction through the flow channel to be manufactured.

4. Method according to claim 3, wherein the drilling process is started in a region of a leading-edge of the side-walls defining each flow channel, continues in the flow wise direction of each flow channel, and terminates in a region of a trailing-edge of each side-walls.

5. Method according to claim 2, wherein for each flow channel at least one center line of the flow channel will be calculated from the contours of the side-walls defining said flow channel.

6. Method according to claim 5, wherein the drilling process is performed in a way that the axis of each drill-hole is approximately in parallel to the or each center line of the flow channel to be manufactured, whereby an intake-opening of each drill-hole is located adjacent to a leading-edge of the side-walls defining the flow channel to be manufactured, and whereby the outlet-opening of each drill-hole is located adjacent to a trailing-edge of the side-walls defining the flow channel to be manufactured.

7. Method according to claim 5, wherein for each flow-channel a plurality of center lines are calculated, the direction of the center lines is a function of contours of the side-walls defining said flow channel, and the contours of the side-walls is a function of a radial position within said side-walls.

8. Method according to claim 6, wherein for each flow-channel a plurality of center lines are calculated, the direction of the center lines is a function of contours of the side-walls defining said flow channel, and the contours of the side-walls is a function of a radial position within said side-walls.

9. Method according to claim 3, wherein prior to the drilling process in flow wise direction a surface perpendicular to the drilling direction is produced.

10. Method according to claim 1, wherein the drilling process is performed in a way that a drilling tool removes material in an across flow direction of each flow channel, and the axis of the drill-holes is approximately

perpendicular to the flow direction through the flow channel to be manufactured.

11. Method according to claim 2, wherein the drilling process is performed in a way that the drilling tool removes material in an across flow direction of each flow channel, and the axis of the drill-holes is approximately perpendicular to the flow direction through the flow channel to be manufactured.

12. Method according to claim 10, wherein the drilling tool removes material by drilling pocket-like drill-holes starting from an outside diameter of the rotor in a radial direction towards a platform of said rotor.

13 Method according to claim 11, wherein the drilling tool removes material by drilling pocket-like drill-holes starting from an outside diameter of the rotor in a radial direction towards a platform of said rotor.

14. Method according to claim 11, wherein after the drilling process is finished the removal of material in the region of said flow channels is completed by a milling process, a milling tool removes the material remaining after the drilling process in the region of said flow channels.

15. A method for manufacturing integrally-bladed rotors for gas turbines, comprising the steps of:

defining the contours of a plurality of flow channel recesses in the integrally-bladed rotor, wherein each recess includes side walls forming blade surfaces;

removing a first portion of material in the flow channels by a drilling process; and

removing a remaining portion of material in the flow channels corresponding to the contours of the recesses by a milling process.

16. The method of claim 15, wherein

the drilling process is performed by a drilling tool that removes material by drilling drill-holes, and

at least one of the size of the drill-holes, the pattern of the drill-holes and the axis of the drill-holes is determined from the contours of the recesses.

17. The method of claim 16, wherein

the axis of the drill-holes is approximately parallel to a flow direction of each flow channel.

18. The method of claim 17, wherein the drilling process is started in a region of a leading edge of the side-walls of each recess, continues in the flow direction of each flow channel, and terminates in a region of a trailing edge of each recess.

19. The method of claim 16, wherein for each flow channel at least one center line of the flow channel is calculated from the contours of the side-walls of the recess defining the flow channel.

20. The method of claim 19, wherein

an axis of each drill-hole is approximately parallel to at least one of the at least one center line of the flow channel,

an intake-opening of each drill-hole is located adjacent to a leading edge of one of the side-walls defining the flow channel, and

an outlet-opening of each drill-hole is located adjacent to a trailing edge of one of the side-walls defining the flow channel.

21. The method of claim 19, wherein

a plurality of center lines within each flow-channel are calculated from the contours of the side-walls defining the flow channels, and

the direction of each of the plurality of centerlines is a function of a radial position of each centerline.

22. The method of claim 20, wherein

a plurality of center lines within each flow-channel are calculated from the contours of the side-walls defining the flow channels, and

the direction of each of the plurality of centerlines is a function of a radial position of each centerline.

23. The method of claim 17, further comprising, prior to the step of removing a first portion of material in the flow channels in flow wise direction by a drilling process, the step of:

producing a surface perpendicular to the drilling direction.

24. The method of claim 15, wherein

the drilling process is performed by a drilling tool which removes material by drilling drill-holes, and

an axis of each drill-hole is approximately perpendicular to the flow direction through the flow channel.

25. The method of claim 16, wherein

the axis of the drill-holes is approximately perpendicular to the flow direction through the flow channel to be manufactured.

26. The method of claim 24, wherein

the drilling tool removes material by drilling pocket-like drill-holes starting from an outside diameter of the rotor in a radial direction towards a platform of said rotor.

27. The method of claim 25, wherein

the drilling tool removes material by drilling pocket-like drill-holes starting from an outside diameter of the rotor in a radial direction towards a platform of said rotor.

28. The method of claim 17, wherein

the milling process is performed by a milling tool which removes the remaining portion of material in the flow channels corresponding to the contours of the recesses.

29. The method of claim 25, wherein

the milling process is performed by a milling tool which removes the remaining portion of material in the flow channels corresponding to the contours of the recesses.